



USE OF SYMMETRY IN THE FIELD OF MATHEMATICS AND ITS APPLICATION IN VARIOUS FIELDS

Subhasis Kotoky

Assistant Professor, Kakojan College

ABSTRACT

Symmetry describes the situation in which different parts of an object are identical, allowing the object to be flipped, rotated, or moved without permanently changing its shape. Symmetry is a very powerful and beautiful problem-solving tool and is found everywhere in all areas of art, architecture, nature and mathematics! The three main types of two-dimensional symmetry are reflection, rotation, and translation. Symmetry was taught to humans by nature itself. A lot of flowers and most of the animals are symmetric in nature. Symmetry is something that we observe in many places in our daily lives without even noticing it. It is easily noticeable in various arts, buildings, and monuments. The main objective of this paper is to investigate how symmetry is used in every day life.

KEYWORDS: Rotational Symmetry, Reflection Symmetry, Translation Symmetry. Order of Rotation.

INTRODUCTION

Symmetry comes from the Greek word meaning “to measure together” and is widely used in the study of geometry. Mathematically, symmetry means that one shape becomes exactly the same as another shape when it is moved in any way, such as rotated, flipped, or moved. For two objects to be symmetrical, they must have the same size and shape, and one object must have a different orientation than the first. Even a single object, such as a face, can have symmetry. If we draw a line of symmetry along the centre of our face, we will see that the left side is a mirror image of the right side. Not all objects have symmetry. If an object is not symmetrical, it is said to be asymmetric.

When working with symmetry, the original image is called the pre-image, and the second image is called the image because it is the last step in the process. Just as answering a math problem is the final step in the process, an image is created when an object is rotated or flipped 90 degrees around the X-axis. There are three main types of symmetry: rotational symmetry, reflection symmetry, and point. Symmetry.

Rotational Symmetry:

Rotational symmetry of shape describes how the shape of an object appears the same when it is rotated about an axis. Many geometric shapes appear symmetrical when rotated 180 degrees or an angle clockwise or counterclockwise. Some examples include squares, circles, and hexagons. Scalene triangles are not rotationally symmetrical because their shape is asymmetric. We know that the word “symmetry” is a combination of two words: “sync+metry”. Therefore, to have symmetry, there must be at least two identical sequences.

If a figure is rotated around a centre point and it still appears exactly as it did before the rotation, it is said to have rotational

symmetry. A number of shapes like squares, circles, regular hexagon, etc. have rotational symmetry.

There are many shapes you will see in geometry which are symmetrical rotationally, such as:

- Equilateral triangles
- Squares
- Rectangles
- Circles
- Regular Polygons

Centre of rotation

For shapes or objects with rotational symmetry, the fixed point where rotation occurs is called the centre of rotation. Example: The centre of rotation of a windmill is at the centre of the windmill, and the blades of the windmill originate from here.

Angle of rotational symmetry

In the case of a shape or object with rotational symmetry, the angle it rotates is called the rotation angle. Example: If you rotate a square 90 degrees, it will look the same after rotation. So the angle of rotation of the square is 90 degrees. Likewise, the angle of symmetry of a regular hexagon is 60 degrees, the angle of symmetry of a regular pentagon is 72 degrees, and so on.

Order of Rotational Symmetry

The number of positions in which a figure can be rotated and still appears exactly as it did before the rotation, is called the order of symmetry. For example, a star can be rotated 5 times along its tip and look at the same every time. Hence, its order of symmetry is 5. If we consider the order of symmetry for regular hexagon it is equal to 6, since it has 6 equal sides and is rotated with an angle of 60 degrees.

Rotational Symmetry Letters

There are many capital letters of English alphabets which has symmetry when they are rotated clockwise or anticlockwise about an axis. Some of them are: Z, H, S, N and O. When these letters are rotated 180 degrees clockwise or anticlockwise the letters appears to be same

Reflection symmetry:

Reflection symmetry is a type of symmetry about reflections. Even if there exists at least one line that divides a figure into two halves such that one-half is the mirror image of the other half, it is known as reflection symmetry. It is also known as line symmetry. The line of symmetry can be in any direction, horizontal, vertical, slanting, etc.

Reflection symmetry is a key property of shapes. It occurs when folding a rectangle along a line of symmetry causes the halves to match perfectly. A shape must have at least one line of symmetry to possess reflection symmetry. In addition, one of the symmetrical halves will exhibit lateral inversion, meaning that the left side appears as the right side when reflected, similar to a mirror image.

Translation Symmetry:

Translational symmetry is when something has undergone a movement, a shift or a slide, in a specified direction through a specified distance without any rotation or reflection. The distances between points within the figure will not change. The angles within the figure will not change. The size and shape of the figure will not change. The only thing that changes is its location. It may be moved right or left. It may be moved up or down. It may be moved through a combination of these two, but these are the only possibilities.

In physics, translational symmetry is crucial to foundational laws such as Newton's law of motion and the laws of electromagnetism. For example, let's look at Newton's second law, $F=ma$. This law remains the same regardless of moving the object in any direction.

For a better exploration of the concept, let's differentiate it based on the number of dimensions involved:

- In one-dimension: Translational symmetry means that the object looks the same after moving it along a line.
- In two-dimensions: It refers to moving the object along a plane without any change.
- In three-dimensions: The object appears identical after moving it in any direction within 3D space.

DISCUSSION

Symmetry plays a fundamental role in mathematics and has numerous applications across various fields

Geometry: Symmetry is central in geometry, where it helps analyze and classify shapes. For example, the study of symmetrical polygons, such as squares and equilateral triangles, is crucial in understanding their properties

Group Theory: Symmetry groups are extensively studied in

group theory, a branch of abstract algebra. These groups help characterize the symmetries of objects and patterns, leading to applications in crystallography, chemistry, and physics.

Physics: Symmetry principles underpin many laws of physics. For instance, Noether's theorem connects symmetry and conservation laws, stating that for every continuous symmetry of a physical system, there exists a corresponding conserved quantity. Symmetry also plays a crucial role in quantum mechanics, relativity, and the study of fundamental particles.

Chemistry: Symmetry is utilized to understand molecular structures and chemical reactions. In spectroscopy, symmetry properties help predict and interpret the behavior of molecules. Symmetry operations such as rotations and reflections are fundamental in crystallography to describe the arrangement of atoms in crystals.

Art and Design: Symmetry is widely used in art and design to create aesthetically pleasing compositions. Artists use symmetry to create balance, harmony, and visual interest in their work. Symmetrical patterns are found in architecture, textiles, and decorative arts.

Computer Graphics: Symmetry is employed in computer graphics for rendering, modeling, and animation. Symmetrical transformations such as reflections and rotations are used to manipulate objects in virtual environments. Symmetry detection algorithms are also used in image processing and computer vision.

Music: Symmetry principles are found in music composition and theory. Musical structures often exhibit symmetrical patterns such as repetition, inversion, and retrograde. Symmetry is also studied in the context of rhythm, harmony, and form.

Architecture: Symmetry is a key principle in architectural design, influencing building layouts, façade designs, and interior spaces. Symmetrical structures often convey a sense of stability and order.

Biology: Symmetry is prevalent in biological systems, from the structure of molecules and crystals to the organization of organisms. Biological symmetry is studied in fields like anatomy, genetics, and evolutionary biology.

Computer Science: Symmetry is utilized in algorithms, data structures, and computational geometry. Symmetrical structures and operations often lead to efficient and elegant solutions in programming and software development.

Cryptography: Symmetric cryptography relies on shared keys and symmetric algorithms to encrypt and decrypt data securely. Symmetry ensures that the same key can be used for both encryption and decryption.

Philosophy and Psychology: Symmetry is sometimes used as a metaphorical concept in philosophical and psychological discussions, representing concepts like balance, harmony, and

equilibrium in human thought and behavior. Overall, symmetry serves as a powerful mathematical concept with widespread applications across numerous disciplines, from the natural sciences to the arts and beyond. Its utility lies in its ability to provide insight, structure, and order to complex systems and phenomena.

CONCLUSION

From the above discussion, we come to a conclusion that for an object or figure to be in symmetry it is essential that the object or figure is a perfect balance of size, shape, and angles. Any irregularity in shape or angle makes that figure asymmetrical. Symmetry, the ordering principle in nature, epitomizes balance between opposing sides. It pervades man-made architecture and natural crystalline formations. The precision and beauty of symmetry in nature imply intelligent design. Humans have adopted this principle for iconic creations and symbols.

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